

Ammonia Carbonation and Biomass Pyrolysis for Carbon Management

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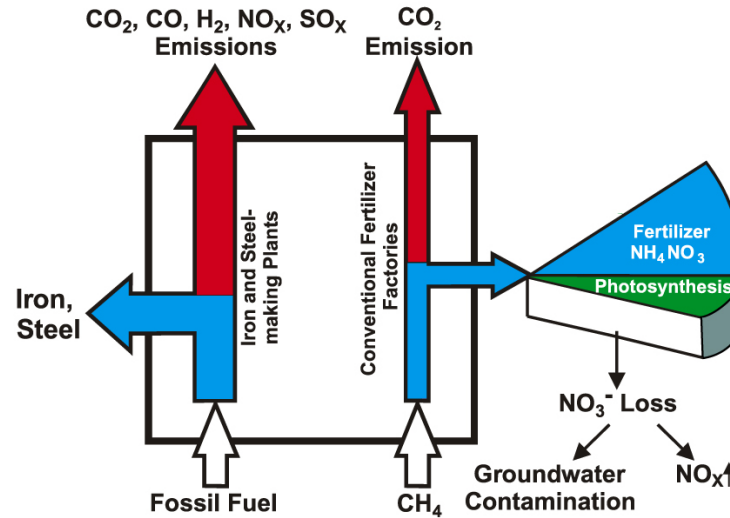
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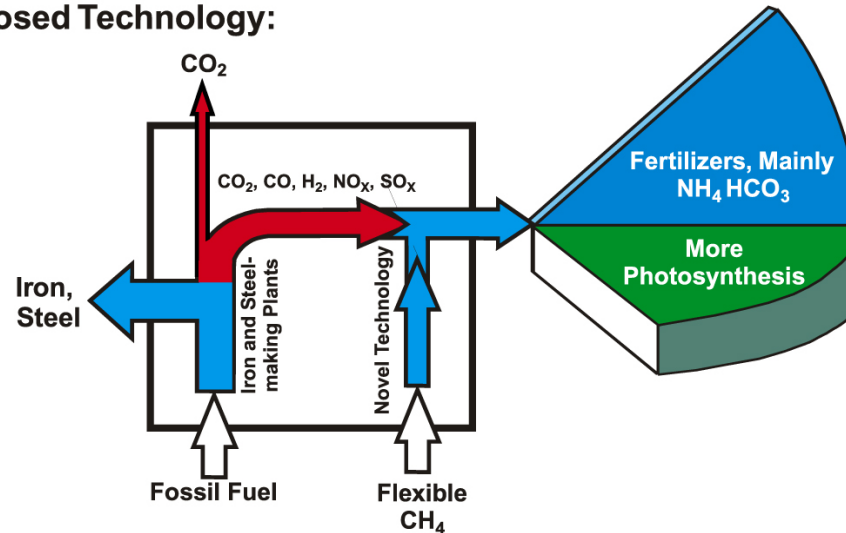
This Technology Could Transform Two Industrial Greenhouse-Gas Emitters into an Environmentally Remediating and Productive System

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The Current Situation:



Proposed Technology:



Validity of the Proposed Technology Concept Can Be Seen by Comparison between Two Fertilizer Production Reactions

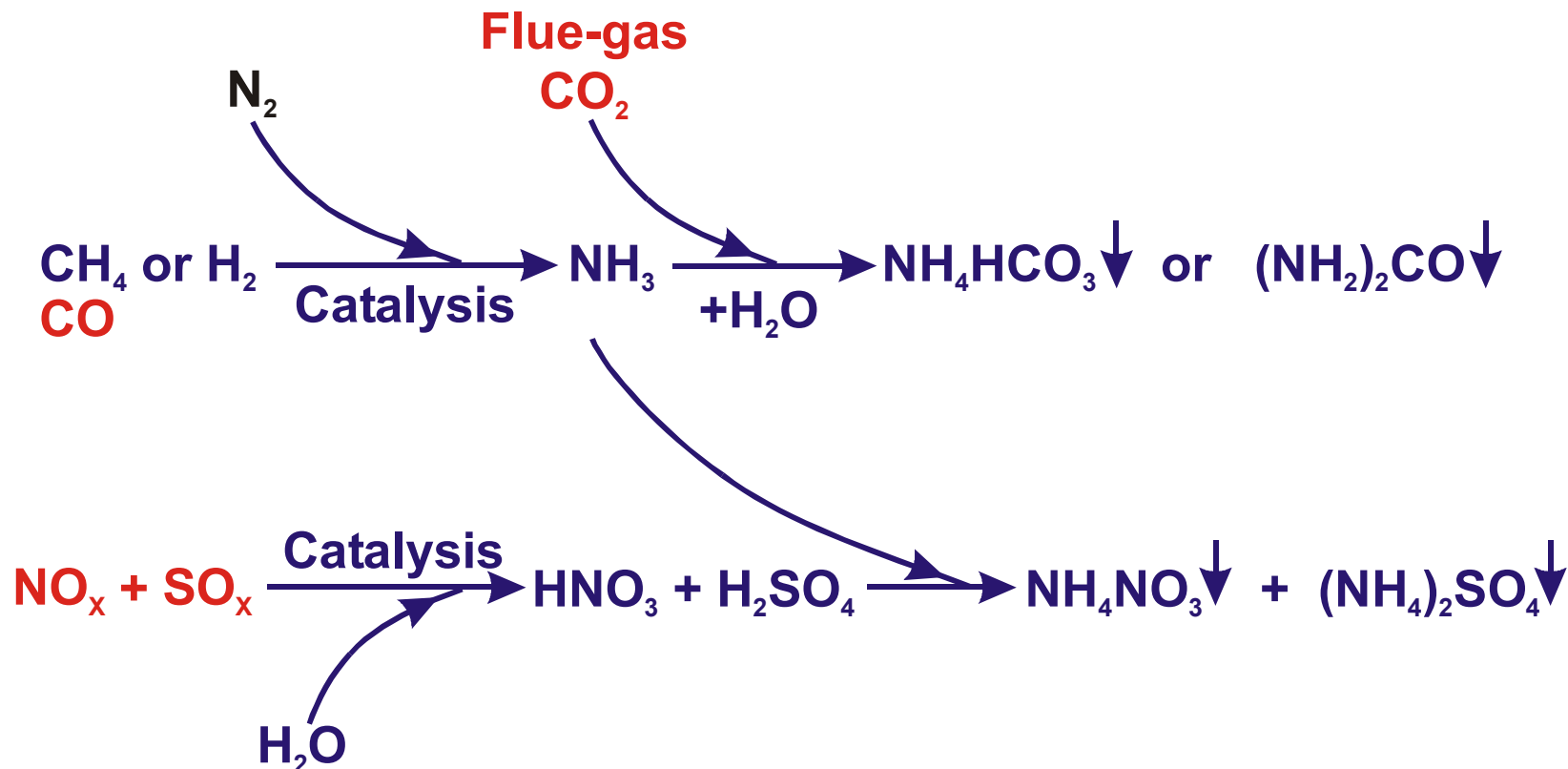
The proposed CO₂-solidifying NH₄HCO₃ production process:



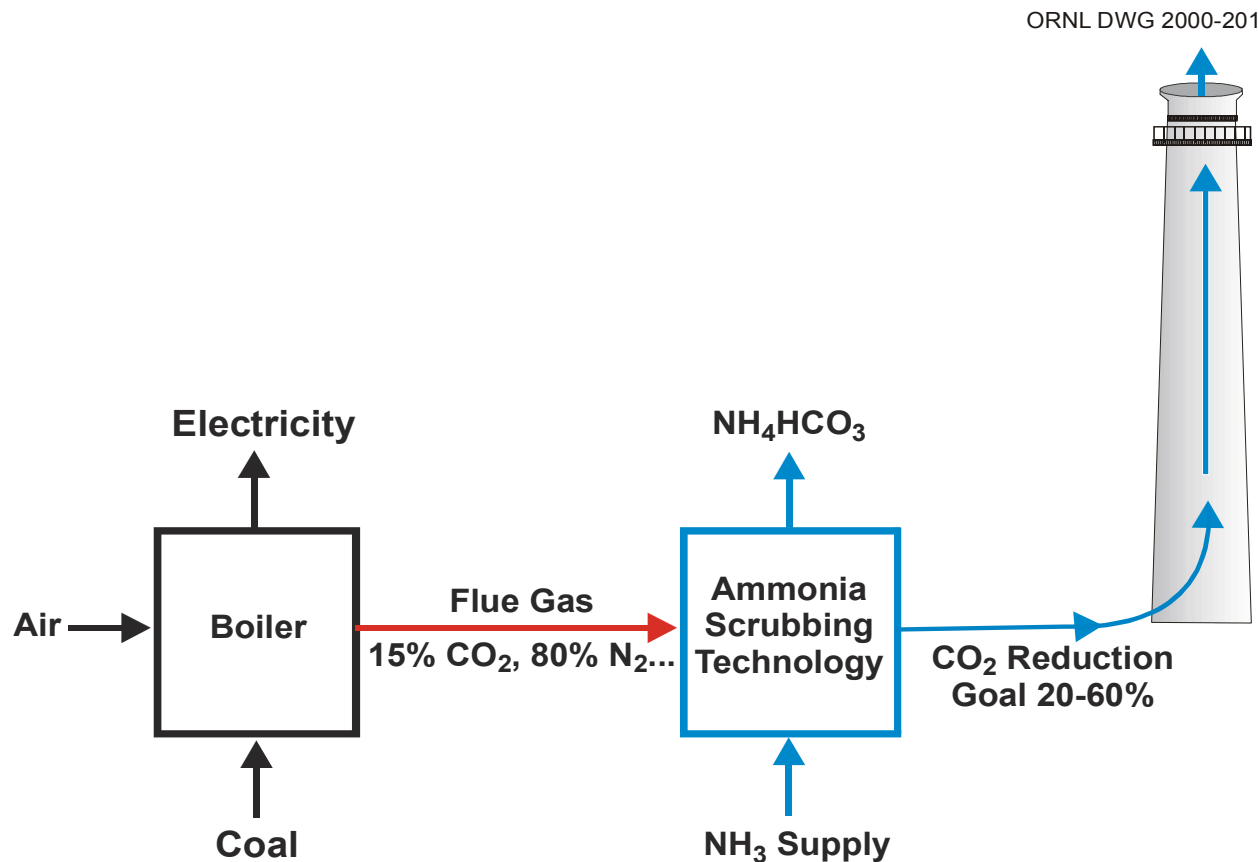
The current ammonium nitrate production process emitting CO₂:



Chemical Pathways for Simultaneous Removal of Major CO₂ and ppm Levels of NO_x and SO_x Emissions by Innovative Application of the Fertilizer Production Reactions



Fundamental Question to Be Answered by Experiment:
Is it feasible to use ammonia-carbonation reaction to remove CO₂ emissions from industrial flue gas?



Market Analysis Showed:

The Proposed Ammonia-Scrubbing Technology Can Be Profitable

(Market Prices from Chemical Marketing Reporter January, 2002)

Product	Market Price \$/lb-mol	Market Price \$/metric ton	To solidify 3.7 ton of CO ₂ (1 ton of carbon), it will:
NH ₃ fertilizer grade	\$1.23	\$159	need \$225 (1.4 ton) of NH ₃
NH ₄ NO ₃ fertilizer grade	\$5.25	\$145	
NH ₄ HCO ₃ fertilizer grade	\$2.63 ^a	\$73 ^a	produce \$481 (6.6 ton) of NH ₄ HCO ₃
NH ₄ HCO ₃ food grade ^b	\$27.06	\$755	

a. Based on a per lb-atom N value of NH₄NO₃.

b. Commonly used as a food leavening agent.

Potential Capacity of the Proposed Ammonia-Scrubbing Technology for Removal of Industrial CO₂ Emissions

Year	World annual nitrogen fertilizer consumption*	Possible capacity for CO ₂ solidification	Potential carbon credit
1994	80 million tons N/year		
2010	100 million tons N/year	315 million tons CO ₂ /year	18.6% (U.S.) or 4.8% (world) reduction in CO ₂ emissions from coal-fired power plants

2025	120 million tons N/year	378 million tons CO ₂ /year	22.3% (U.S.) or 5.76% (world) reduction in CO ₂ emissions from coal-fired power plants
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* Data from: Kawashima, K., K. Okamoto, M. J. Bazin, and J. M. Lynch (1998) "Nitrogen fertilizer and ecotoxicology: Global distribution of environmental pollution caused by food production," Biotechnology Research Series 7:208–219.

A Preliminary Test Reactor System Constructed through a Small Seed Money (\$70K) Project

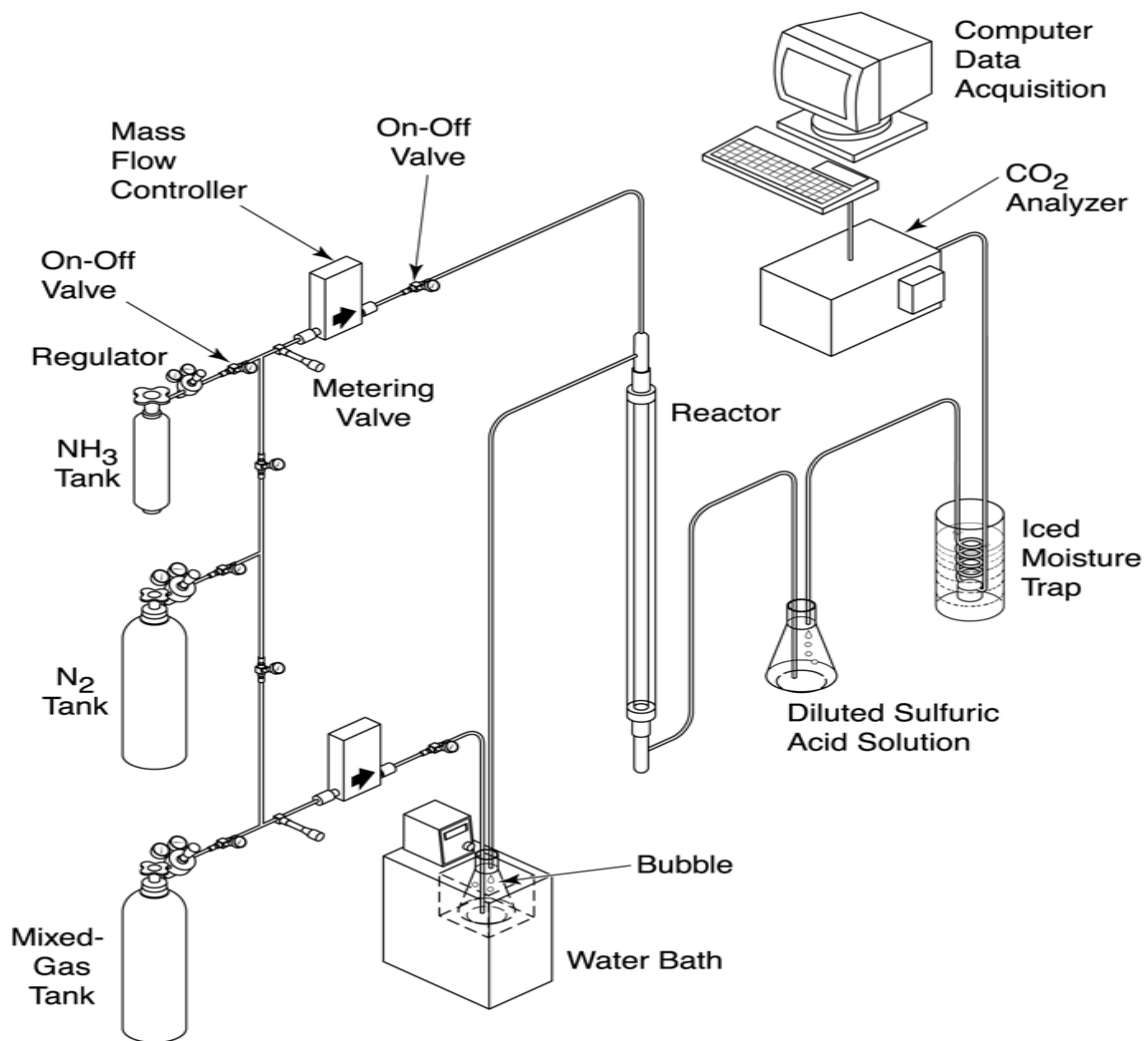


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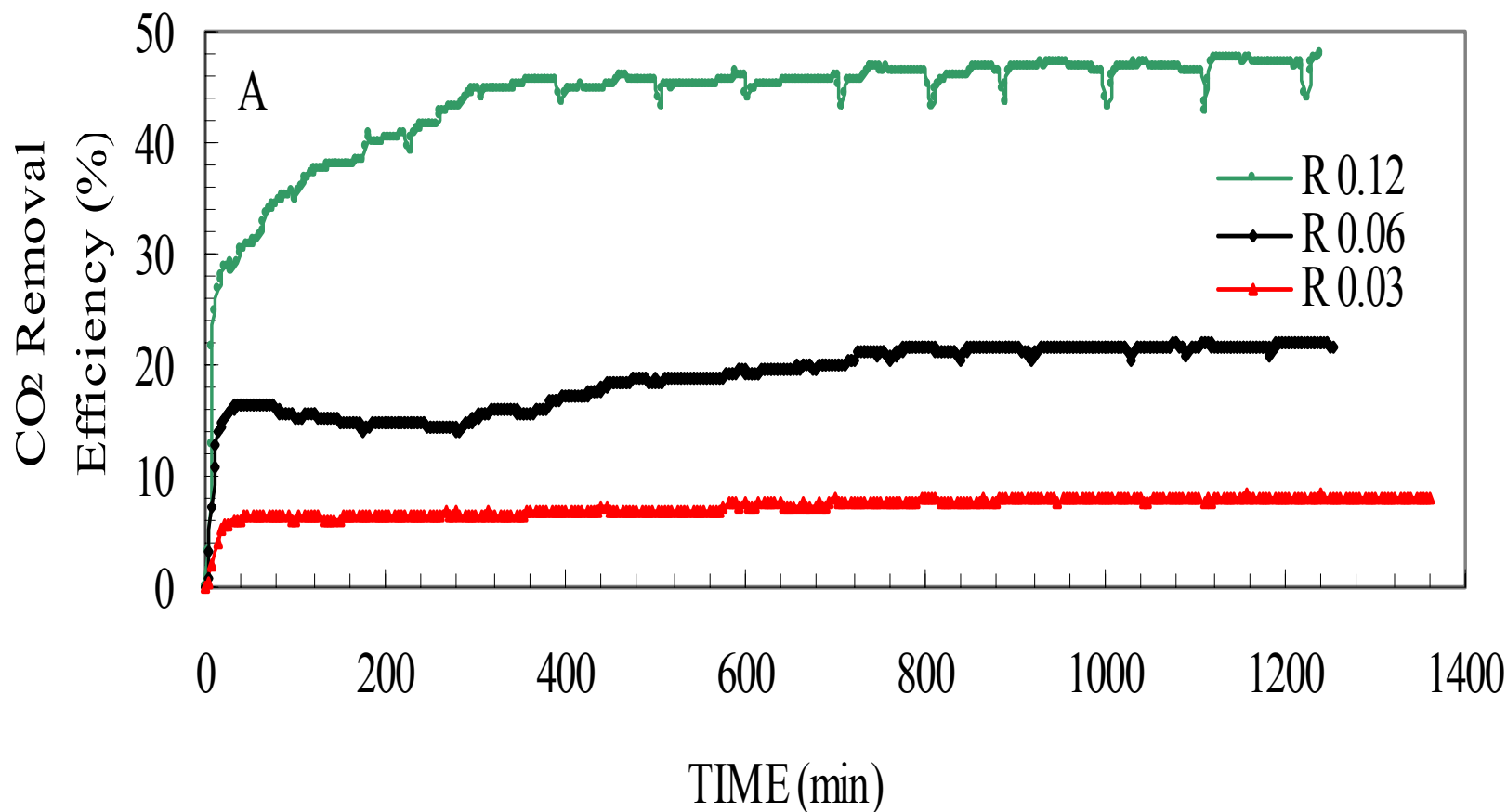


Illustration of the Test Reactor System Constructed at Our Lab

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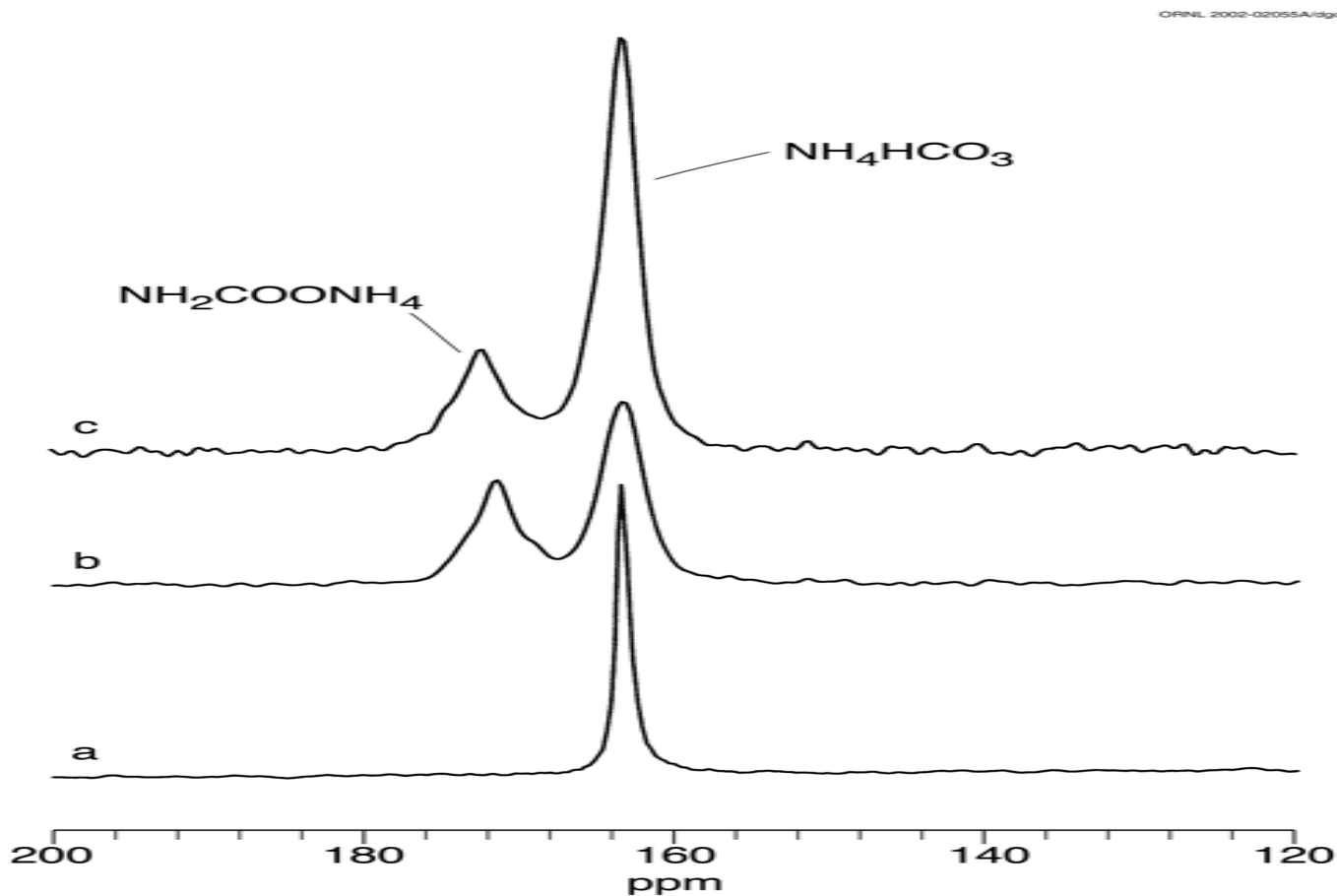
Our Experimental Results: Measurements of CO₂ Removal by Ammonia Carbonation in the Gas Phase



Our Experimental Results: Solid Product Produced by Ammonia Carbonation in the Gas Phase

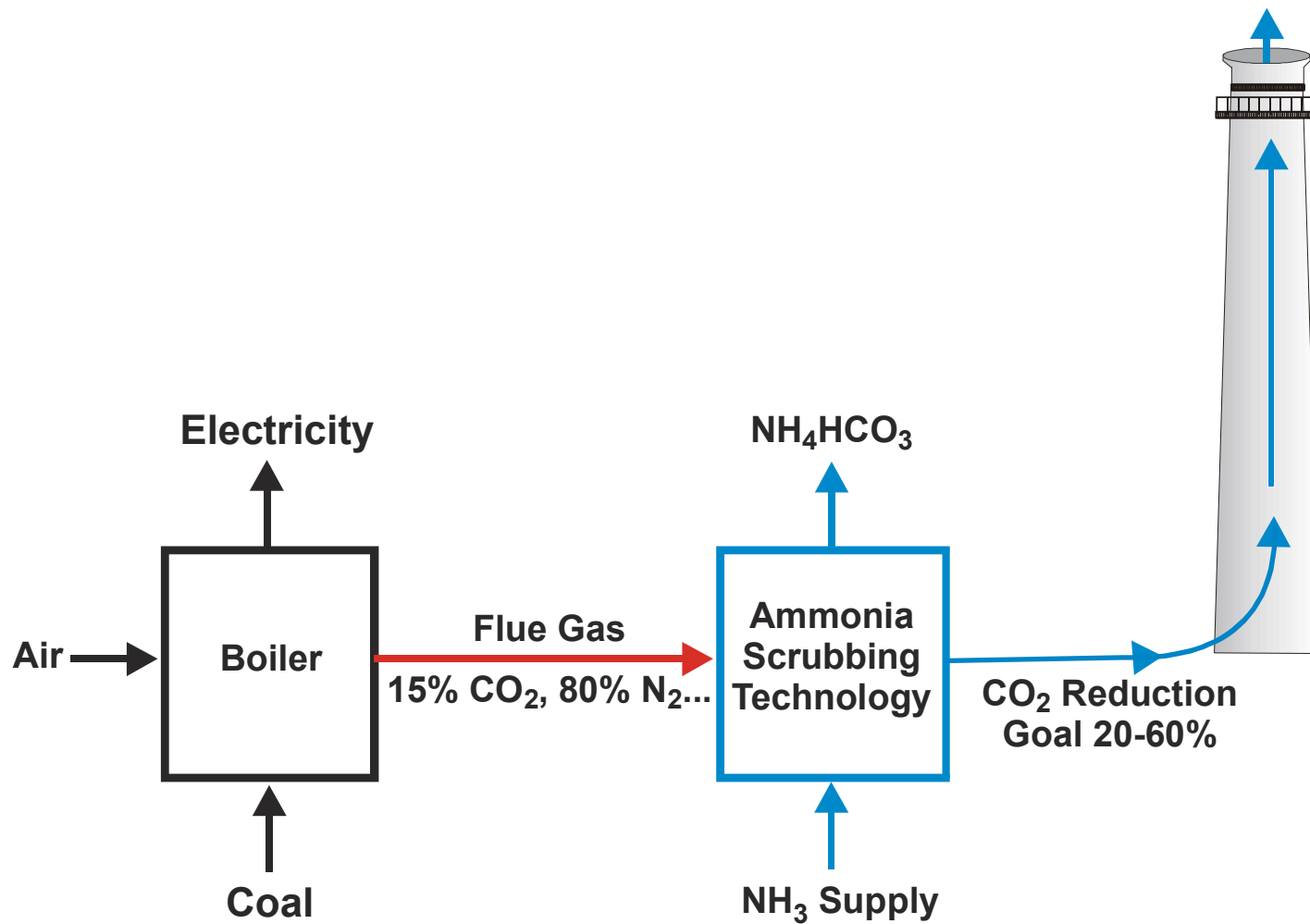


Solid Products (NH_4HCO_3 and $\text{NH}_2\text{COONH}_4$) from Ammonia-Carbonation Experiments Were Identified by NMR Analysis



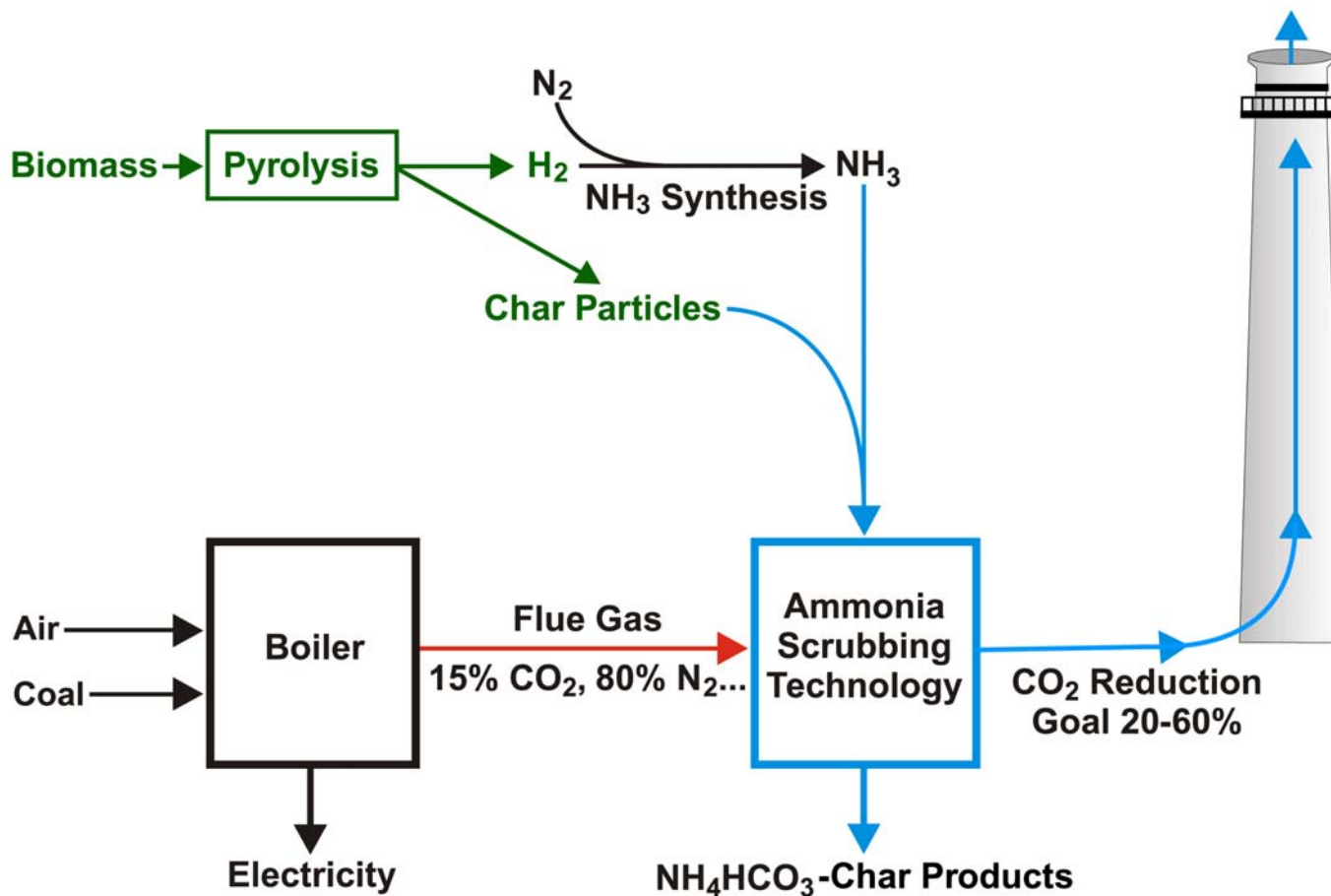
Conceptual Design to Remove CO₂ Emissions in Industrial Combustion Facilities by Ammonia Carbonation

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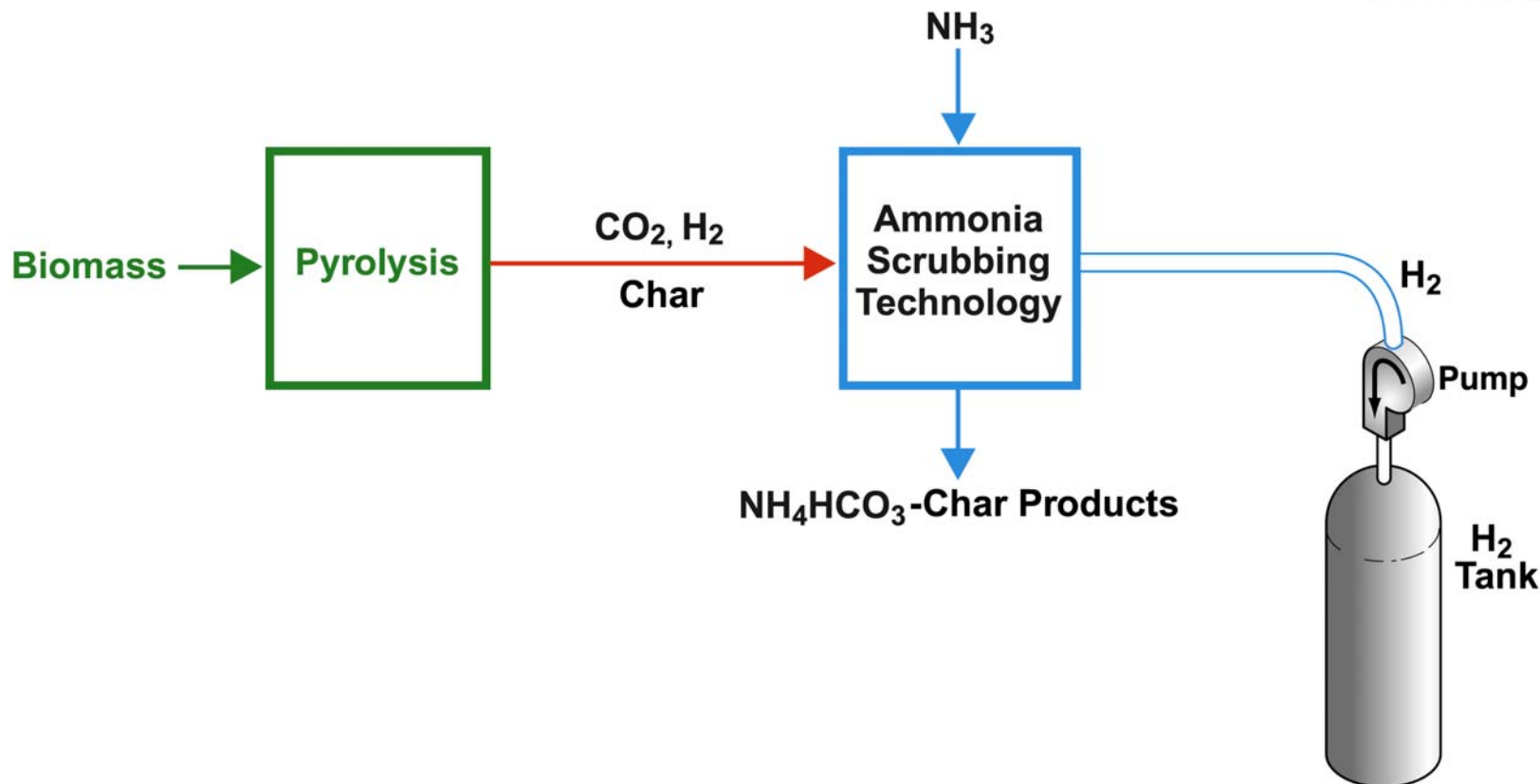
Integration of Ammonia Carbonation and Biomass Pyrolysis for Carbon Management

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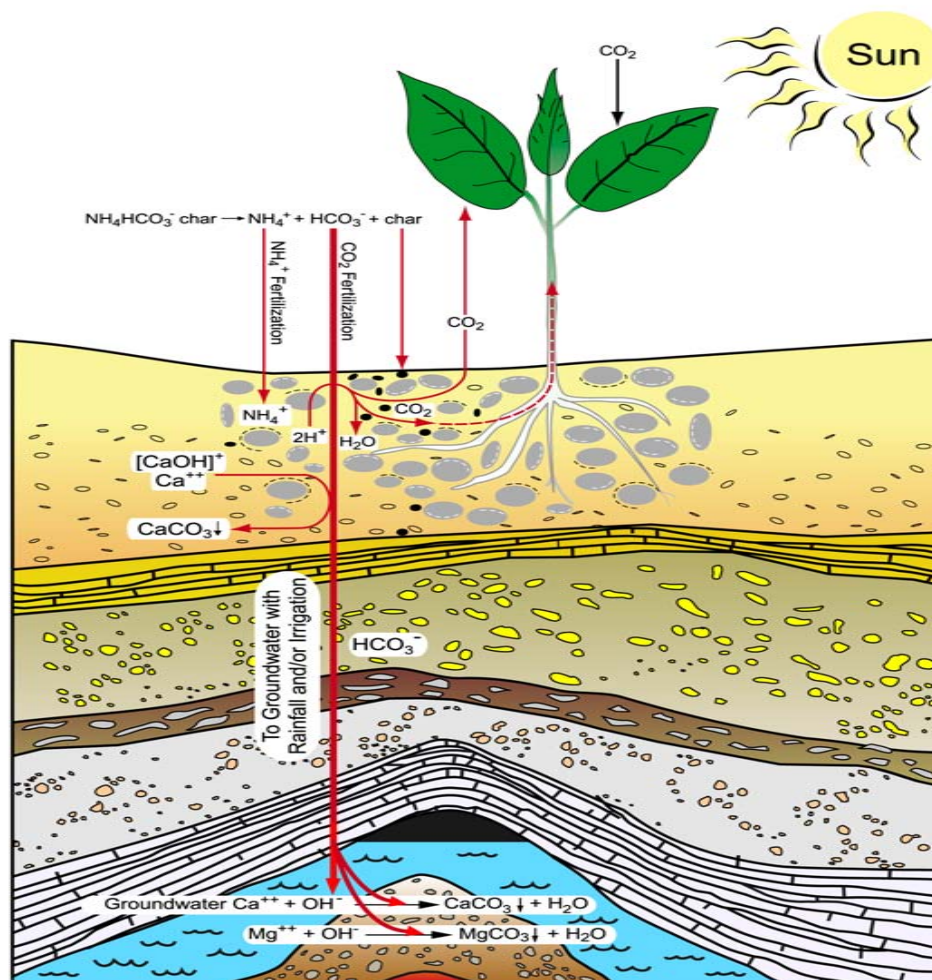
Potential Application of Ammonia Carbonation for Removal of CO₂ from Biomass Pyrolysis to Make Pure H₂

ORNL 2003-02128/vwp



Intelligent Application of NH_4HCO_3 to Enhance Sequestration of Carbon into Soil/Subsoil Earth Layers

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Expected Benefits from the Invention

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